



# FDOT Pipe Practices

## Retaining Walls



*Celebrating 100 Years of Innovation, Mobility and Economic Development*

## Presentation Outline

- Introduction
- Forensic Field Evidence
- Structural Concerns at Walls
- Recommended Solutions
- Discussion and Action Going Forward



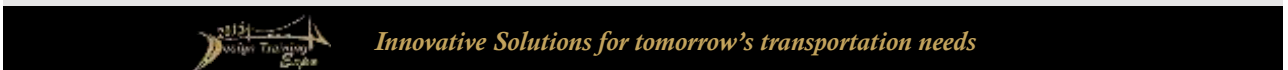
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# Introduction

- Post construction inspection does not show water infiltration into pipes
- Problems in other states
- Pipes sometimes leak, especially if envelope moves
- Structures costly to repair
- Multidisciplinary team



**D7 #150226  
US19 over  
Drew**



**D1 #160216  
SR60 over  
Kissimmee River**



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**TP #750607,  
SR 91 SB  
Ramp to SR  
429 NB**



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**TP #750607**



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**TP  
#750607**



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**D4 #930487,  
ABANDONED  
PIPE  
RAMP I-95 NB  
over  
MERCER/CSX**



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**D4  
#930487**



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**D4 #930487**



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**D4 #930487**



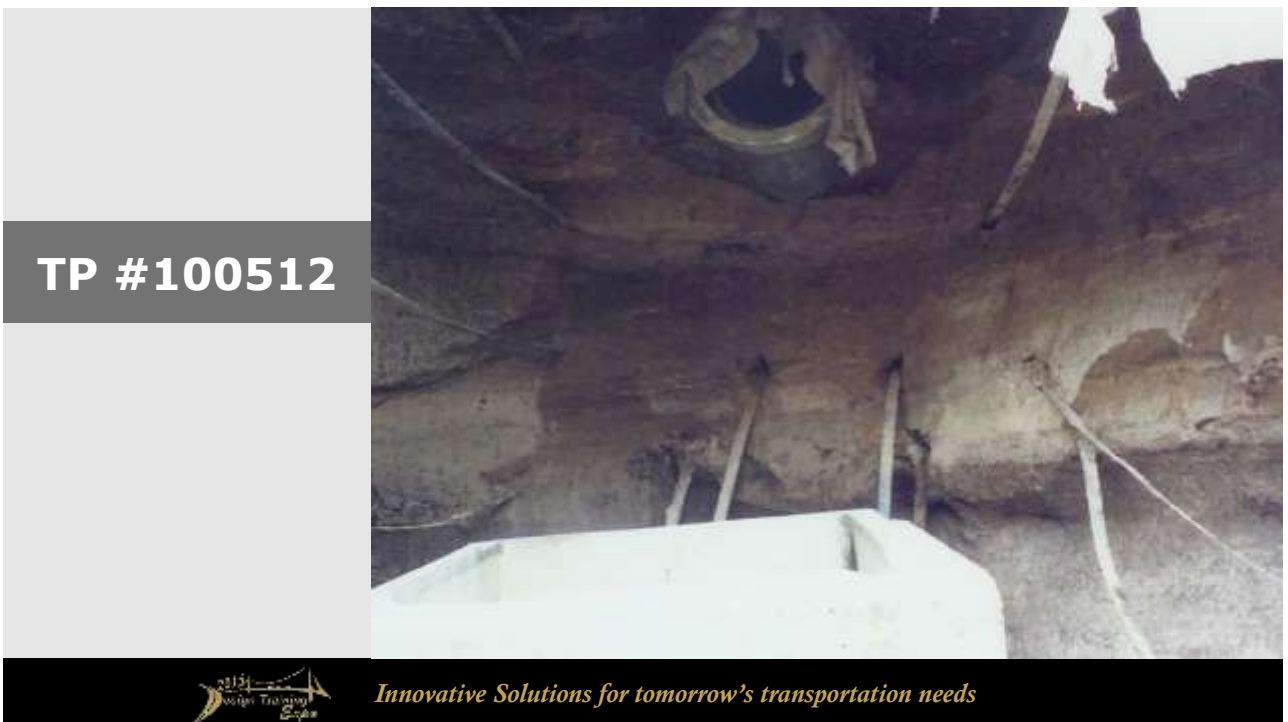
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**TP #100512  
SR568  
(VETERANS  
EXPRESSWAY)  
over CULSA  
TRACE**



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**D2 #720631,  
PIPE LEAK  
I-95 NB over  
ST. JOHNS  
RAMP E to  
PARK AVE.**



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**D2  
#720631**



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**D3 I-110  
RAIN EVENT**



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**D3 I-110**



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D3 I-110



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D3 I-110



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**D3 I-110**



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**D3 I-110**



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## Drainage Lines and Structural Integrity of Retaining Walls (Structures)



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# Problem

- Some of the potential problems with damaged lines or leaking pipes;
  - Soil migration
  - Settlement
  - Accelerated corrosion of MSE straps
  - Deterioration of panels/wall facing
  - Hydrostatic forces



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## Mechanically Stabilized Earth (MSE) Walls

- GRI report # 38 – 82 wall failures
    - Internal soil instability  $\approx 26\%$
    - External soil instability  $\approx 6\%$
    - Internal water related  $\approx 46\%$
    - External water related  $\approx 22\%$
- } 68%

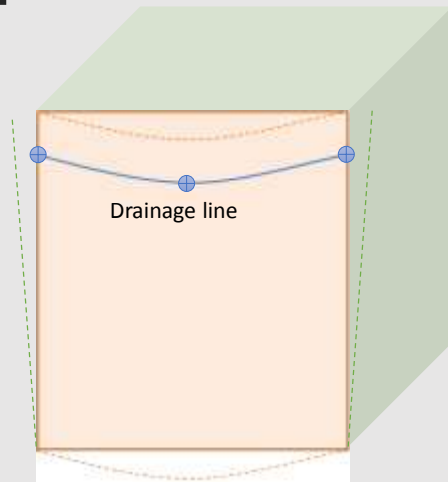


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# Problem

- Differential settlement
  - Elongation
  - Deformation
- Construction Tolerances
  - Elongation



Deformed section



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## Settlement Limits

2015 SDG		
Wall Type	Maximum Total Settlement (in)	Maximum Differential Settlement (%)
Gravity (C.I.P.)	2.0	0.2
Segmental Block	6.0	0.5
MSE ( $\leq 5'$ Panels, $\leq 30 \text{ ft}^2$ )	6.0	1.0
MSE ( $> 5'$ Panels, $> 30 \text{ ft}^2$ )	6.0	0.5
C.I.P. Concrete Cantilever	2.0	0.2

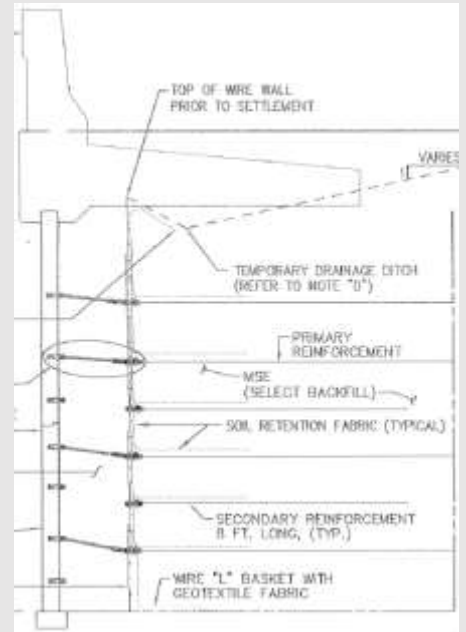


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## Special Case- 1



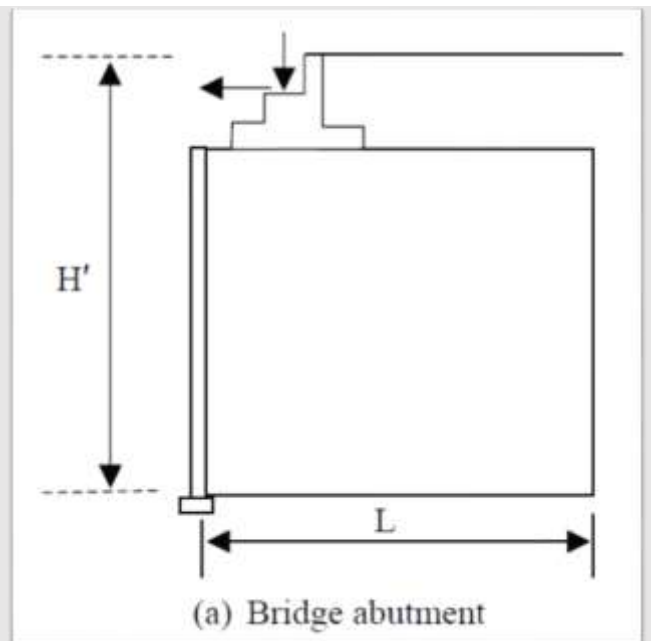
When settlement is expected to exceed the limits; **two-stage walls** may be an alternative



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## Special Case- 2

Abutments on Spread Footings



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# MSE Walls

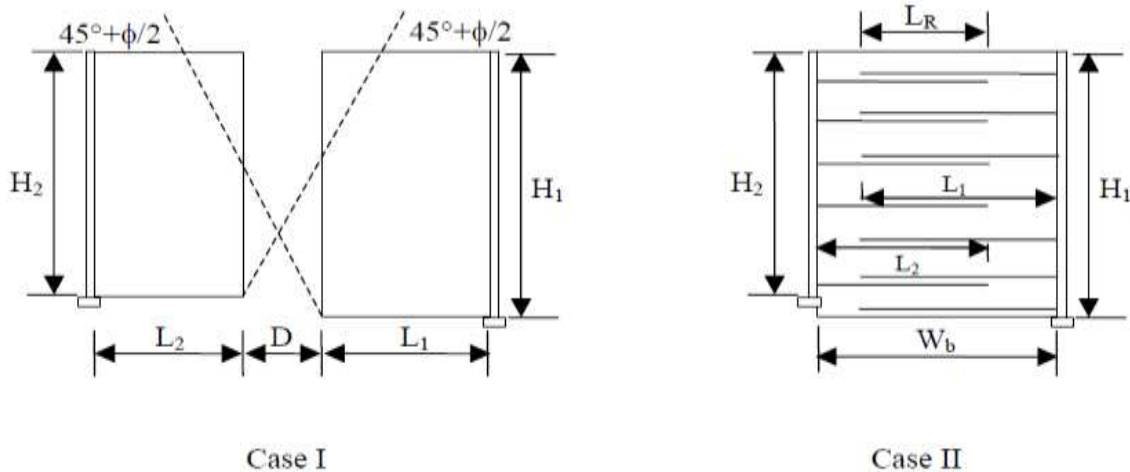
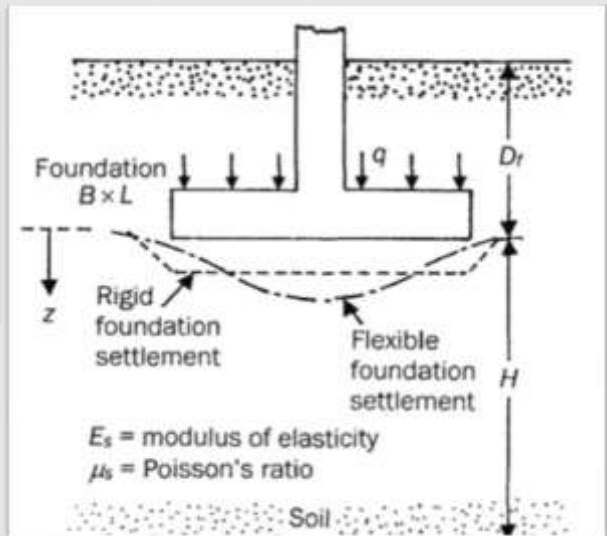
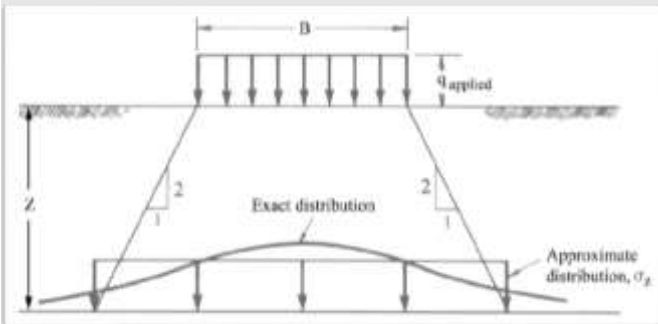


Figure 6-9. Back-to-back MSE walls.



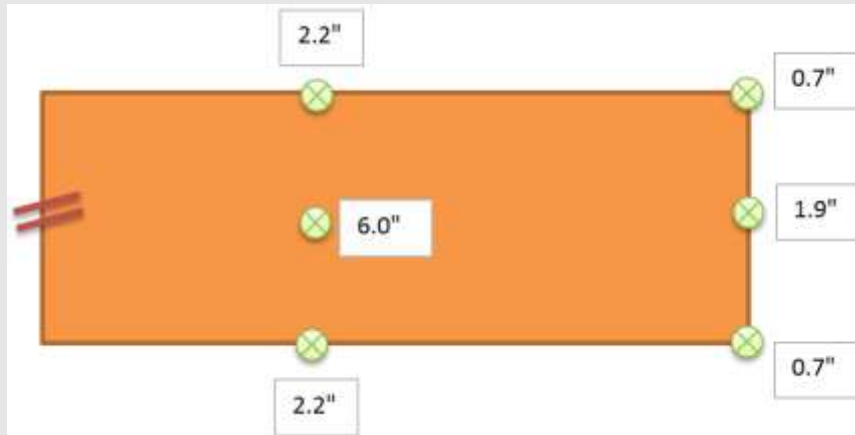
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# Stress and Settlement



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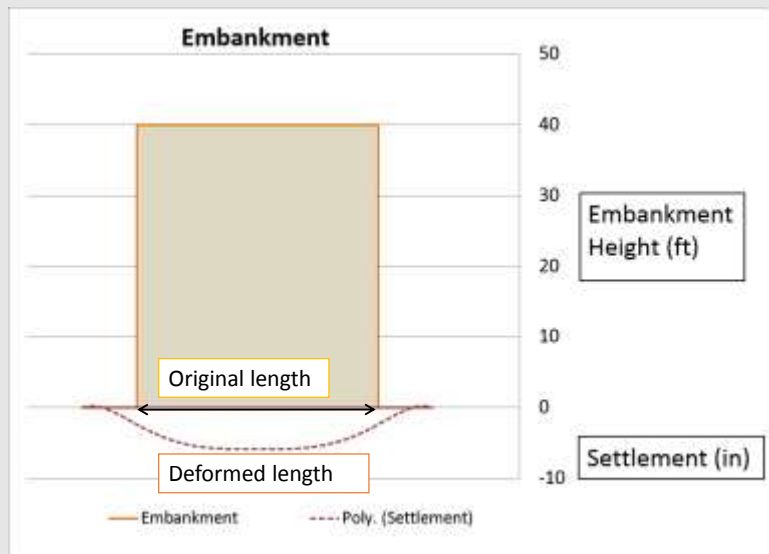
## Total Settlement (Top View)



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## Pipe Elongation

Elongation due to settlement for the 40' tall sample embankment < 1"

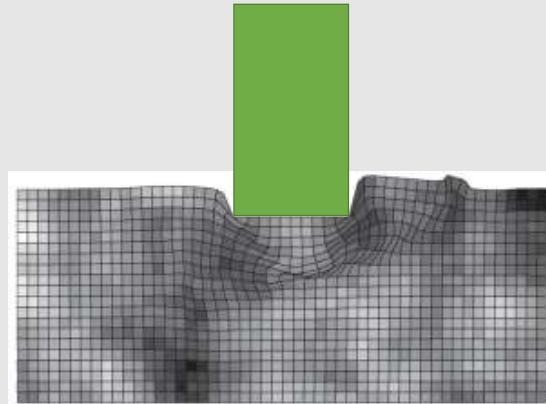


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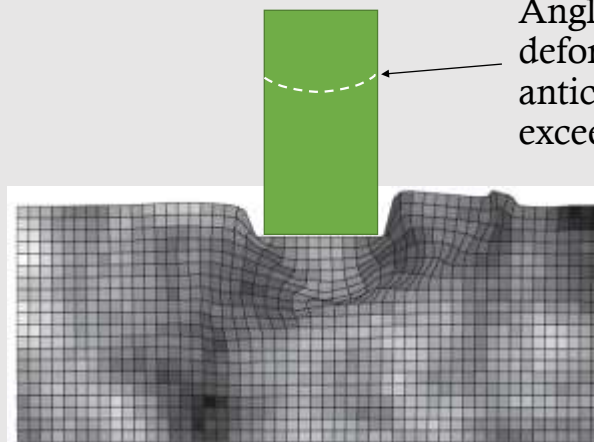
## Variable Subsurface Profile

- Variability in soil strength can cause significant additional differential settlement
- Elongation in this case can be larger than under homogeneous soil conditions



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## Pipe Deformation



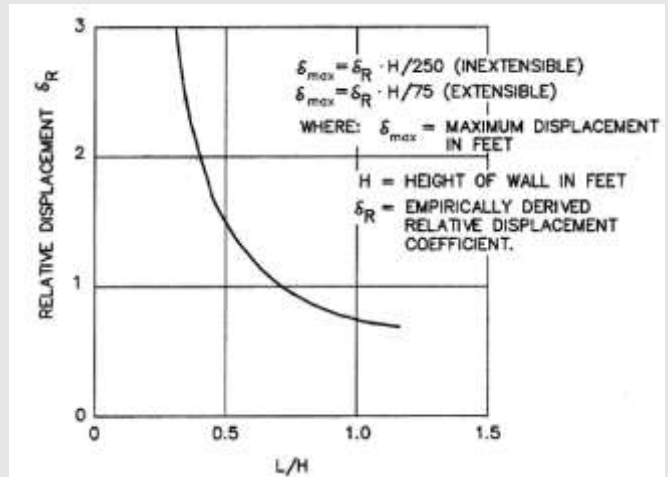
Angle of deformation is not anticipated to exceed 5 degrees



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# Lateral Displacement

- AASHTO C11.10.4.2
  - A first order estimate of lateral wall displacements on **firm foundations**
  - If significant vertical settlement is anticipated lateral displacements could be considerably greater.



For example:  $[(1)(40')(12)]/75 = 6.4''$



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# Lateral Displacement

For  $L = 0.7 H$

Metallic (inextensible) reinforcement  $\approx 3/4$ -in. per 10 ft of wall height

Geogrid (moderately extensible) reinforcement  $\approx 1$  in. per 10 ft of wall height

Geotextile (extensible) reinforcement  $\approx 1.5$  in. per 10 ft of wall height

Based on 20 ft high walls, relative displacement increases approximately 25% for every 400 psf surcharge. Experience indicates that for higher walls, the surcharge effect may be greater.

20' to 60' Wall height;  
 Metallic  $\approx 1.5''$  to  $4.5''$   
 Geotextile  $\approx 3''$  to  $9''$



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# Construction Tolerances

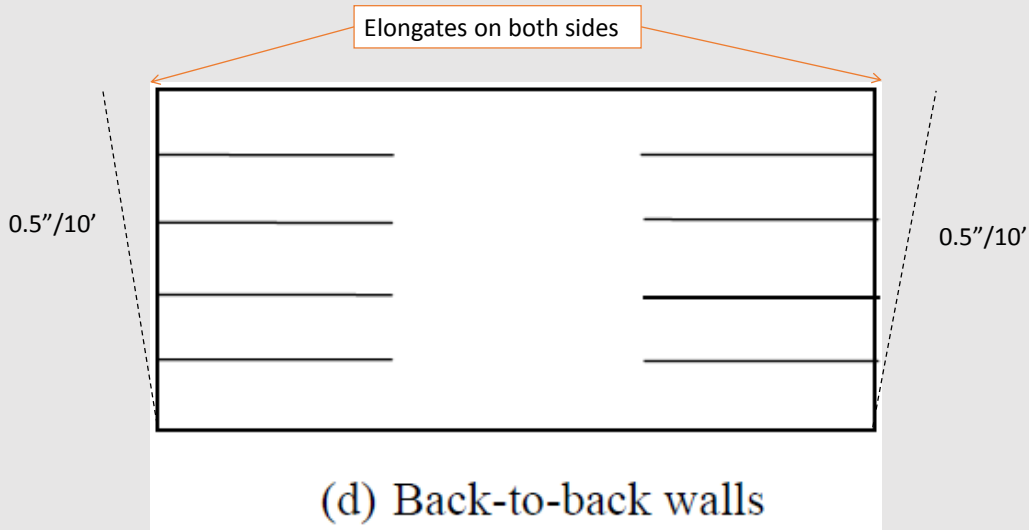
**548-8.4.1 Tolerances for Permanent Walls:** Ensure that vertical tolerances (plumbness) and horizontal alignment tolerances do not exceed 3/4 inch when measured with a 10 foot straightedge. The maximum allowable offset in the joint between precast components is 3/4 inch. The final overall vertical tolerance of the completed wall (plumbness from top to bottom) shall not exceed 1/2 inch per 10 feet of wall height. Horizontal and vertical joints between precast components shall not be less than 1/2 inch or more than 1-1/4 inches. Walls which do not meet these tolerances will not be accepted by the Department and must be removed and reconstructed at no cost to the Department.

For example;  $0.5'' \times 4 = 2''$  (for a 40' tall wall)



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## Construction Tolerances



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## Summary (Structures)

Drainage lines in proximity to retaining walls have to be able to handle the estimated elongation and deformation without any leaks.



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## Principles of Proposed Solutions

- Design for strains and loads
- Identify first indicator of leakage
- Reduce probability of pipe joint leakage under expected strains
- Insitu repair: allow for future pipe lining
- Ensure that pipes are installed fully home



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# Implementation

- Structures/Roadway Bulletin
  - Remove pipe guidance in Structures Manual
  - Publish changes in Drainage Manual
- Spec Change (January 2016 Book)



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## Walled Sections in General

- Resilient Connectors on Drainage Structures
- Pipes should have 6" overhang on internal wall of structure
- Hydraulic design allows for future pipe liner
- No French Drains
- Inspect to ensure that pipes are installed fully home



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## Soil Zones at Walls

Soil Zone	Requirements	Design Intent
A	Elongation Tolerant Pipe	Likely not to leak and used when probable first indicator of leak is topside settlement
B	Leak Avoidance Pipe	Probable first indicator of leak is wall damage: pipe must endure unique loading with no chance of leakage
C	No pipes allowed	Probable first indicator of leak is bridge damage.



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## Elongation Tolerant Pipe

- No leakage at 2" pullout with 10.8 psi
  - Pipe manufacturers pursuing qualification
- Post-installation joint gap verification



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## No Leakage Pipe

- No longitudinal conveyances allowed
- Only welded joints allowed
- Site specific LRFD analysis for pipes under walls

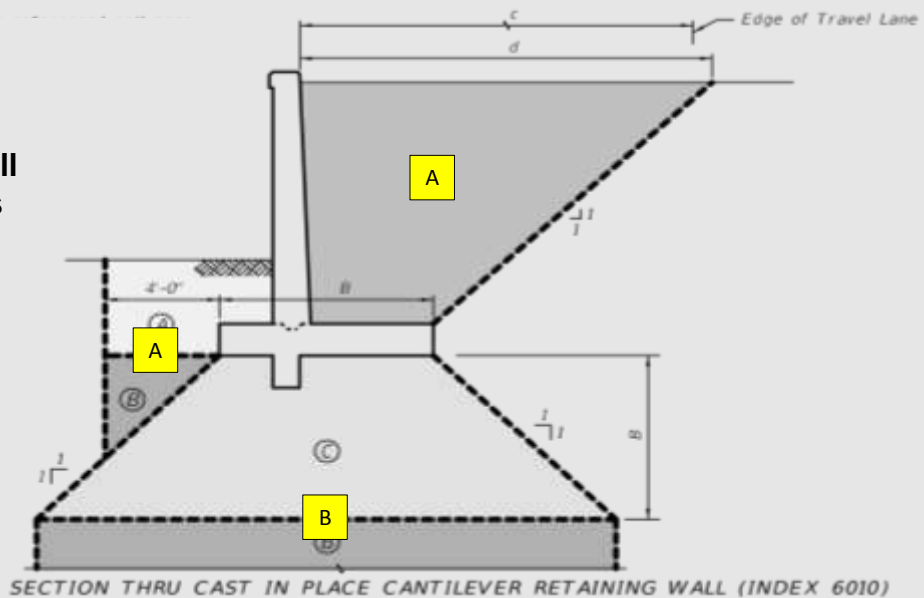


## Additional MSE Wall Requirements

- Zone A pipe within upper 5 ft. below top of wall, longitudinal pipes OK
- Zone B pipe below 5 ft., including vertical drains
- If a trunk line > 24" is required, move it to the median
- Connect to external pipes after MSE embankment is in place
- 2-stage MSE walls: no transverse pipes
- No HDPE pipe within the strap zone

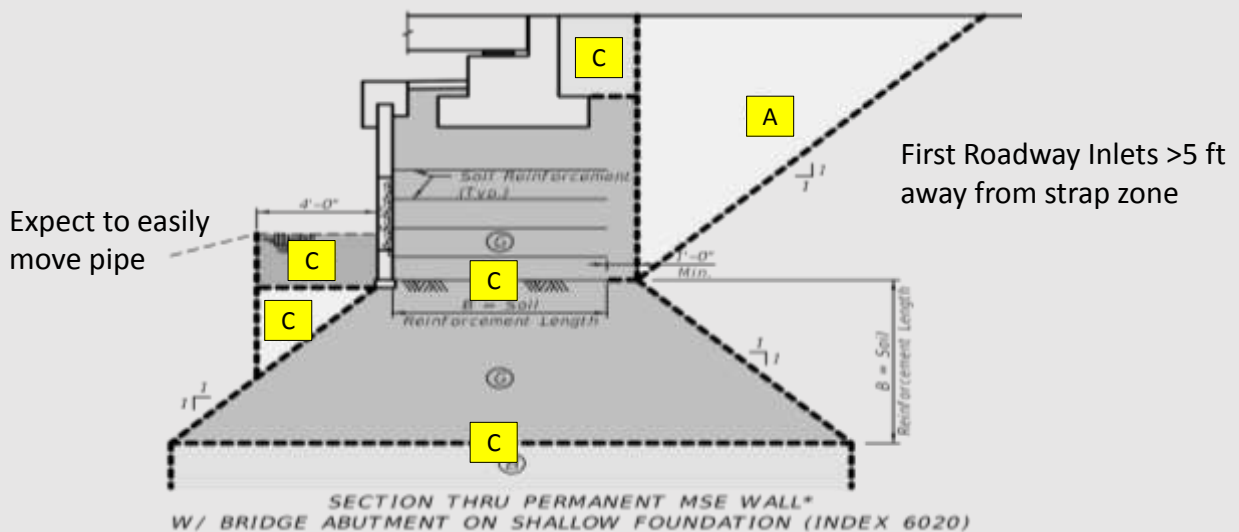


## Cast in Place Wall Soil Zone Details



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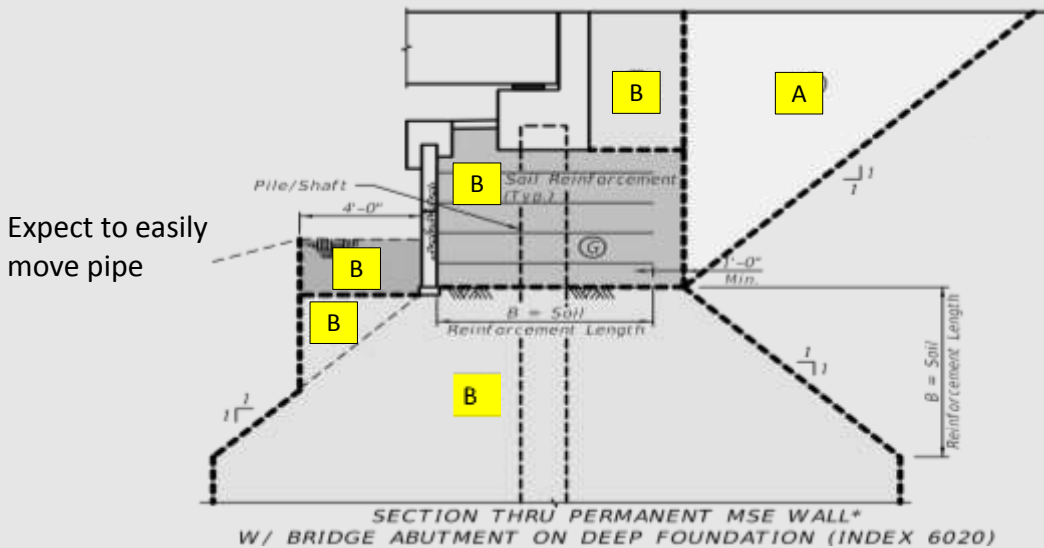
## Permanent MSE Wall Soil Zone Details (1 of 2)



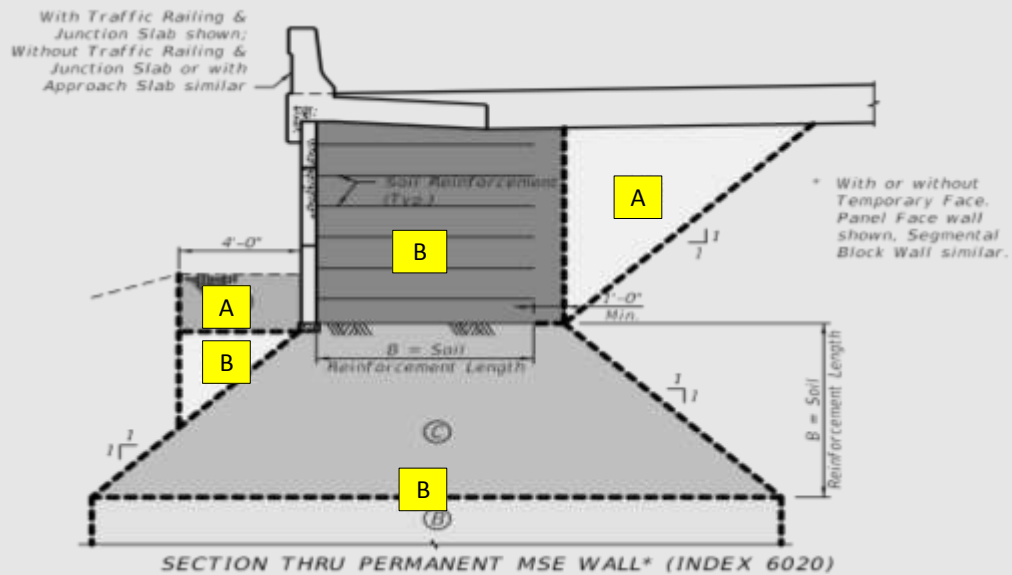
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## Permanent MSE Wall Soil Zone Details (2 of 2)



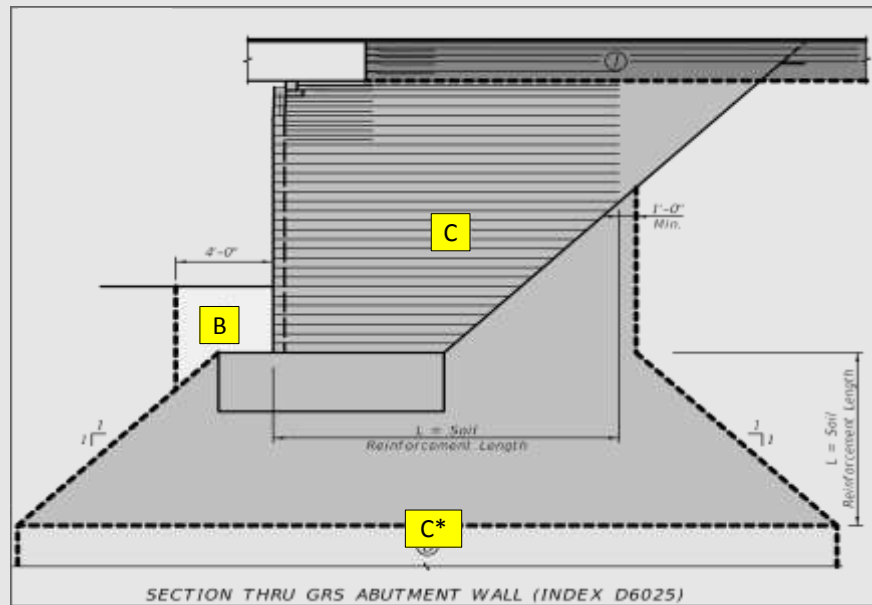
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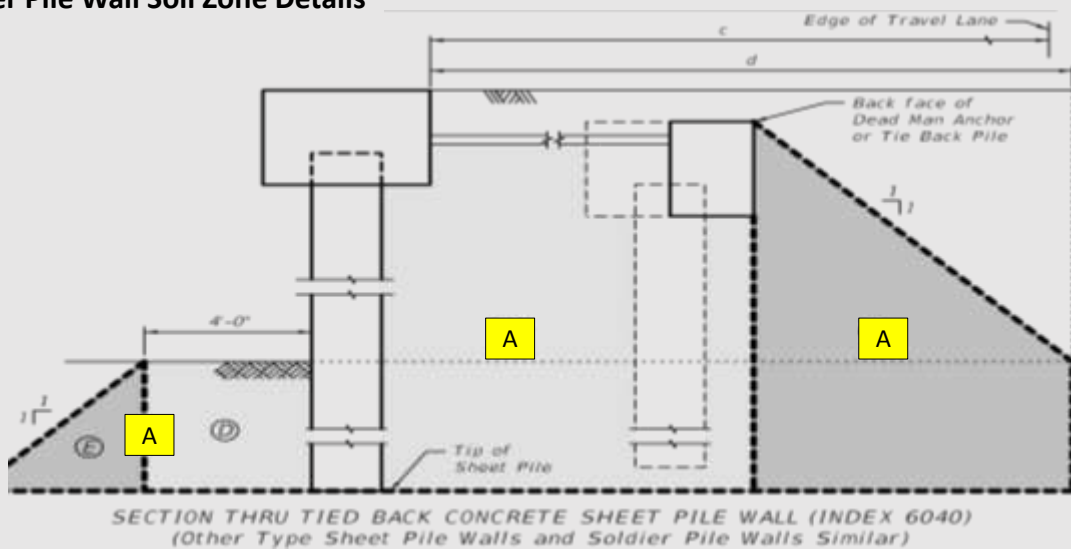
## GRS Abutment Wall Soil Zone Details

\* Pipe causes problematic hard spot within soil under footer



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## Soldier Pile Wall Soil Zone Details



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